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Forest Service

APPALACHIAN FOREST EXPERIMENT STATION

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OBSERVATIONS ON REQUIREMENTS FOR RESTOCKING CUTOVER LOBLOLLY AND SHORTLEAF PINE STANDS

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Foreword

This Station recently was asked for an opinion on the measures necessary to insure maximum restocking of loblolly and shortleaf pine stands. Mr. Barrett's typewritten memorandum was reproduced and rather widely circulated by several agencies, and the Station has received so many requests for copies that we are issuing herewith the memorandum in its original form.

No claim is made that the conclusions are based on an exhaustive program of research. However, the individual observations cited, most of them on loblolly pine, all seem to show that an unexpectedly large number of seed is essential for the rapid, consistent restocking of cutover land. The memorandum points out that adequate seed sources can be provided in several ways. It is emphasized that the observations were made in the Carolinas and Virginia, and that soil, climatic, and other differences may make them entirely inapplicable elsewhere.

R. E. McArdle

R. E. MCARDLE
Director

August 3, 1940

MEMORANDUM FOR DIRECTOR

Subject: Requirements for restocking cutover loblolly and shortleaf pine stands, with special reference to the Virginia Seed Tree Law.

This memorandum is prepared in response to Mr. V. L. Harper's RS-AP-SILVICULTURE, Harvest Cuttings, letter of July 26, and State Forester Pederson's letter of July 29. Mr. Pederson asks for a statement as to what type of cutting operations should be followed to insure the maximum restocking of cutover lands with loblolly or shortleaf pines, and for an opinion on the adequacy of the new Virginia seed tree law. This memorandum presents briefly the information available at the Appalachian Forest Experiment Station regarding the adequacy of varying numbers of seed trees for restocking forest lands and the measures necessary to insure maximum restocking. The data and observations upon which the memorandum is based were collected in the coastal plain and Piedmont regions of the Carolinas and Virginia.

Adequacy of Seed Trees

Mr. Pederson is certainly correct in his observations of the great variability of pine reproduction in both the presence and absence of seed sources. Among the most puzzling of these is the presence of a fine stand of saplings with no seed source in sight. If one has the time to run down the history of such stands and can find people who remember it, the answer is usually that (a) the original stand was cut during the fall and winter of a heavy seed crop, or (b) seed trees were left and cut later after reproduction had been established, or (c) adjacent bodies of timber seeded in the cutover area and were subsequently cut. Stands are occasionally observed where two or three seed trees per acre have apparently completely restocked an area. Sometimes the seedlings in such stands have not all come from the existing seed trees only, but from that part of the stand that was cut or from adjacent bodies of timber which may have been cut after they had assisted in the restocking of the adjacent area on which seed trees were left. These and other reasons to be discussed later cause great variation in restocking.

Table 1 summarizes our available information on the seed production of loblolly pine. It is based upon seed counts of nearly

500 felled trees from 32 stands in the Piedmont and mid-Atlantic Coastal Plain. Density of the 32 stands ranged from one-third to full stocking. Both very poor and very good seed years were represented by the stands. Column 2 of the table is based upon all stands. The figures in this column reflect the effect of both good and poor seed years. They are the best data we have to show average annual seed production for a period of years. Column 3 is based upon stands with good seed years only and provides the best data we have to indicate what production would be during the average good seed year. Differences between columns 2 and 3 are not differences between good and poor seed years. Actually these differences show the additional amount of seed dispersed during a good seed year over the average annual production of seed for a period of years including those of both good and poor seed production.

Table 1.-Seed production of loblolly pine in forest stands of one-third to full stocking.

Diameter breast high	Average number of seeds per tree annually	Average number of seeds per tree in stands with better than average seed years
inches		
6	0	0
7	100	200
8	220	380
9	490	650
10	880	1,100
11	2,140	3,450
12	3,800	6,050
13	5,700	8,700
14	7,900	11,400
15	10,500	14,300
16	13,300	17,100

Inspection of this table would lead one to believe that very few seed trees of almost any size would provide adequate stocking. However, there is a tremendous differential between the number of seeds laid down on the ground and the number of established seedlings resulting therefrom. A case in point is shown by the results of an experiment in which this Station cooperated with Duke University. During the winter of 1935-36, a strip 132 feet wide had been cut through a sawtimber stand of loblolly pine approximately 70 years old, located on Duke Forest. In the fall of 1936 a good crop of cones was produced by the forest stands which bordered this strip. Seed traps were established in the clearcut strip and the caught seeds counted at intervals during the period of seed dissemination. At the end of this time it

was found that 281,000 seeds per acre had been laid down in the clear-cut strip. Two years later, seedling counts showed an average of 900 seedlings per acre on this area. A few seeds were produced both before and after the 1936 crop but exact quantities are not known. The outstanding fact is that a natural production of something over 281,000 seeds per acre resulted in only 900 established seedlings per acre. This number of seedlings is adequate, but not maximum, for forest production.

Many reasons are known for the tremendous differential which exists between number of seeds laid down and number of seedlings resulting therefrom. Among the known reasons are the following:

(1) Percent of seeds viable. Not all seeds produced are fertile and the percent which are fertile is likely to vary from year to year.

(2) Failure of some seeds to fall where germination or establishment is possible. Some seeds will fall on old logs, strips of bark, thick layers of hardwood leaves, or dense clumps of grass, where conditions for germination and early survival are poor.

(3) Consumption of seeds by birds and rodents. This is a highly important and tremendously variable factor. Rodents such as mice and many species of birds are known to consume enormous quantities of pine seeds. Much of the seed crop falls during bird migration seasons. A large flock of birds may or may not happen to land on a cutover area after most of the seeds have fallen. If they do, they are quite likely to search out and consume a high proportion of the crop. Populations of seed-consuming rodents are known to be cyclical. Some years they will be present in large numbers; other years relatively few will be present. Furthermore, some particular sites seem to be preferred by a given species, others are avoided. It has been demonstrated that mice will travel for as much as one mile to get to cutover areas where presumably they find more shelter from predatory birds in brush piles and the tops of cut trees than they do in the surrounding woods where the ground surface offers less cover. The distance of one mile is many times the distance over which mice will travel in their ordinary search for food where there has been no abnormal disturbance of forest cover.

(4) Early mortality of seedlings subsequent to germination. Here again birds come into the picture, by picking seed coats off the newly emerged cotyledons. Ants have been known to destroy pine seedlings in the very early stages of their development. Unseasonable weather, such as pronounced droughts

or unusually hot periods during the time of germination may result in high mortality. For example, a study conducted during 1939 on the Lee Experimental Forest in Buckingham County, Virginia, showed that 16.4 percent of the loblolly pine seedlings which germinated in the spring died before October. For shortleaf pine, 15.1 percent of the seedlings which germinated in the spring died by October. The early summer months in 1939 in Buckingham County were characterized by better than average rainfall. During the same season similar observations were made in Union and Laurens Counties, South Carolina. Here 50.4 percent of the loblolly seedlings which germinated in the spring died by October and 52.1 percent of the shortleaf pine seedlings died during the same summer. However, at this location the summer was characterized by drought periods and subnormal rainfall.

The successful natural regeneration of any area to pine, therefore, is dependent not only upon the presence of a seed source, but also upon the absence of enough of the adverse factors mentioned above to allow a portion of the seeds to become established as seedlings. These factors may be present in any one of innumerable combinations and it is obvious that their influence upon the seed crop will be extremely variable. This explains why a given number of seeds might result in an excellent young stand in one case and in almost no restocking in another. One outstanding fact, however, is indicated by the above discussion and will be substantiated by later additional data. This is that to insure as many as 1,000 established seedlings per acre, the forest manager must plan his cutting to provide from 200,000 to 300,000 seeds per acre.

The Virginia seed tree law requires that 3 pine trees per acre, 10 inches in diameter outside bark at the stump, must be left on the ground, or, in case this is impossible, not less than 4 pine trees per acre, 9 inches in diameter at the stump. In the following discussion the size of seed trees will be referred to in breast-high diameter rather than stump diameter. It is a fairly safe assumption that a tree 10 inches in diameter at the stump will be 9 inches in diameter at breast height, and a tree 9 inches in diameter at the stump will be 8 inches in diameter at breast height. Referring to column 2 of Table 1, we see that the average production for trees 9 inches in diameter at breast height is 490 seeds per tree annually. Three of them would then produce on the average about 1,500 seeds per year. For 8-inch trees, production of seeds is 220, and 4 of them would produce 880 seeds. Data in Table 1 are based upon seed production in stands with little or no disturbance by recent cutting. General observation by many foresters indicates that partial cutting stimulates cone production. Cone counts which we have made of seed trees before and after partial cutting indicate that release from competition stimulates cone production of residual trees by approximately 100 percent.

Therefore, after release by cutting it is reasonable to assume that 8- and 9-inch trees will produce twice the number of seeds that they did before the cutting. Applying this correction factor to the average production of three 9-inch, or four 8-inch trees, we find that the Virginia law provides for an average annual dispersal of from 1,760 to 3,000 seeds. In the light of our present knowledge, we do not believe that this number of seeds per acre will insure consistent, adequate restocking within a reasonable period of time, say 10 years. Of course, a few seedlings will survive each year and their accumulation will eventually produce possibly 1,000 trees per acre. Such stands are very common and frequently produce lumber of low quality, because the larger trees which become established first grow up without early competition and therefore produce knotty trunks.

Consider what seed dispersal under the Virginia law would be during good seed years. Column 3 of Table 1 furnishes the basis for the calculation below:

Table 2.-Seed dispersal under present Virginia law during good seed years.

No. of seeds per tree in good seed year	No. of seeds corrected for increased cone production caused by release	Breast high diameter	Number of trees under Virginia law	Total probable seed production
380	760	8	4	3,040
650	1,300	9	3	3,900

The last column of the above tabulation shows that the present Virginia law would provide for dispersal of from 3,000 to 4,000 seeds per acre during good seed years which come at intervals of from 2 to 4 years. To recapitulate: our existing data show that average annual production over a period of years would probably range from 1,760 to 3,000 seeds per acre, and that during good seed years production would be from 3,000 to 4,000 seeds per acre, a rather small increase for the good seed years. This small difference is not in accord with well founded opinion. However, inspection of Table 1 shows that a very substantial difference between average annual production and production during good seed years occurs in trees larger than 10 inches d.b.h. Trees under 10 inches are pretty poor seed producers even in good years. There are exceptions to this, of course. Any forester can cite cases of 6-inch trees with good cone crops but present knowledge indicates that such cases are the exception, and that small trees cannot be counted on for consistent seed production.

Without doubt fine young stands will be produced in some cases, poorly stocked stands will be produced in others, and almost no reproduction will occur in still others. It should be said, however, that the leaving of seed trees will doubtless raise the general level of stocking over a large area. If we will consider an area of 2 or 3 counties where 3 or 4 small seed trees per acre had been left and a similar area with no seed trees, there is very little question that the former area will contain more pine regeneration than would the second area, but all our evidence indicates that pine regeneration on the area with seed trees would vary considerably. One landowner would have a fine young stand and another might have a very poor scattering stand of limby trees.

One other bit of rather recent evidence, as yet unpublished, should also be considered in connection with seed tree methods of regeneration. As a result of 10 years' intensive observation on 2 different selectively cut sawtimber stands of loblolly pine, we have found a high mortality in the smaller trees. Thirty to forty percent of trees 8 inches in diameter, breast high, died, and about 25 percent of all 9-inch trees died. These figures refer to stands which are over 50 years old. No evidence of this kind of mortality has been found in stands under 40 years of age. A high proportion of the mortality in the 8- and 9-inch trees left on the ground after logging was apparently associated with damage suffered during the cutting. Trees which had logging wounds over a foot long in any dimension and also those which had as much as 25 percent of their limbs broken showed very heavy mortality rates. Undamaged pines with small, narrow crowns also died. The causes of this mortality are unknown but it is possible that the sudden opening of the stand results in soil moisture and temperature changes to which the smaller and weaker trees are unable to adapt themselves. In stands over 50 years of age, therefore, it is reasonable to expect that one-fourth or one-third of the seed trees left on the ground may die unless they are chosen from the very healthiest, uninjured trees.

Measures Designed to Insure Maximum Restocking

Present knowledge indicates two broad types of measures essential to insure maximum restocking. First of these are the cutting or harvest operations. The second are cultural measures which may or may not be necessary, depending upon the presence or absence of hardwood invasion in a given locality.

Cutting operations:

It has already been indicated that 200,000 to 300,000 seeds per acre must be laid down before we can count consistently on adequate regeneration. Reference to Table 1 allows for computing the number of trees of various sizes which would be required to produce between

200,000 and 300,000 seeds per acre. In mature stands which are ready for sawtimber harvest, there are in general two ways in which this number of seeds can be obtained. These are described below:

(a) The two-cut method. Under this method all but about 40 large seed trees per acre would be harvested in a first cut. The number, of course, would vary with the size of trees, but forty 13-inch trees will provide about 200,000 seeds per acre annually on the average. After regeneration has become established in 5 to 10 years, the overstory of seed trees should be removed in a second cutting to allow development of the new stand.

Two examples of cutting of approximately this type have been under observation by the Appalachian Forest Experiment Station for 10 years. One cutting, made in 1930, left on the ground approximately 30 trees ranging in diameter from 7 to 22 inches. By use of Table 1 it is estimated that approximately 65,000 seeds per acre were provided annually by this stand. Evidence now on the ground indicates that reproduction was completed within the first three years so that during this period our best information is that the parent stand provided somewhere in the neighborhood of 195,000 seeds. Inspection of the area during June 1940, showed an excellent reproduction, well distributed over the entire unit, and reproduction counts on numerous small plots showed from 2,000 to 5,000 seedlings per acre. In the second example, cutting left on the ground 85 trees per acre varying in size from 6 to 18 inches. Reproduction arising after this cut numbered 5,400 per acre. From Table 1 it is estimated that during the 3-year reproduction period, 580,000 seeds per acre were dispersed by the parent stand. In this case a heavier original cutting could have been made and still sufficient reproduction obtained.

(b) Strip, or group selection: Here the timber is harvested by clearcutting in long, narrow strips or roughtly circular groups. After each clearcut area is reproduced, adjacent strips or groups are harvested until the last remaining mature timber is to be cut. This should be cut during a heavy seed year or by the two-cut method. The main consideration in this type of cutting is that no part of the clearcut area be further than about 5 chains from the nearest body of standing timber. It has been found that beyond 5 chains, solid bodies of seed-producing pine cannot be counted upon to reproduce adjacent areas <u>consistently</u> at a rate of 1,000 seedlings per acre or more.

An example of successful reproduction by strip cuttings has already been cited. Clearcutting in selected circular patches in a mature stand of loblolly sawtimber following a heavy seed crop in 1936 resulted in establishment of pine seedlings at the rate of from 10,000 to 15,000 per acre.

General observation in the coastal plain region of Virginia and the Carolinas indicates that methods approximating either (a) or (b)

above show desirable regeneration more consistently than do other types of cutting, provided there is protection from fire following the cutting.

Cultural measures:

Sometimes even these methods fail, particularly where a pine-hardwood mixture exists. Here seed-bed conditions are not desirable for the best germination of pine seed. Pine seeds require contact with the mineral soil for best germination and early survival. Hardwood leaf litter creates a condition which makes such contact unlikely except for a very small proportion of the number of seeds produced. Breaking up of this litter to expose part of the mineral soil increases the amount of pine reproduction which becomes established. An experiment covering this point was conducted in a mixed stand of oak and shortleaf pine by the Appalachian Forest Experiment Station. A strip through the forest was broken up by very shallow plowing. No attempt was made to lay back straight furrows as is done in field cultivation. The plowing merely attempted to break up the surface leaf litter and roots to a depth of about 4 inches. Seven years later this plowed strip supported shortleaf pine seedlings at the rate of 26,000 per acre. Immediately adjacent, but unscarified areas supported only 400 shortleaf pine seedlings per acre. In pine-hardwood forests of this type, a good guarantee of successful regeneration would be a scarification of the surface prior to seed fall. The number of seedlings obtained in the scarified ground during the above experiment is many thousands more than enough for adequate regeneration, but in practical application it would not be necessary to scarify the entire surface as was done in the experiment. Strips 3 or 4 feet wide at 6- or 8-foot intervals would be sufficient. Frequently the logging itself will expose sufficient mineral soil in the mixed oak-pine type to provide for adequate regeneration. But, in cases where logs are not dragged or skidded across the ground, but most of them loaded directly on trucks or wagons from the place where they fall, there may result a poor reproduction of pine.

Stand improvement operations will be necessary in some areas to release pine reproduction from the competition of undesirable hardwood sprout and seedling growth. We have found in studies completed but not yet published that hardwood invasion of pine stands is an active ecological development in the Piedmont region of the Carolinas and Virginia. That such a trend is under way has also been a matter of general observation by some foresters. The most obvious sign of this invasion is the development of hardwood understories in pine timber. General observation leads us to believe that this hardwood invasion is active in coastal North and South Carolina and Tidewater Virginia, but to a more limited extent than is the case in the red clay soils of the Piedmont. Our studies indicate that where even a fairly dense hardwood understory is present before cutting, the pine is quite capable of

outgrowing the hardwoods on the better pine sites, say those of site index 90 or better. On poorer pine sites where hardwoods are creeping into the pine stands and have produced a dense understory, it is questionable whether the new growth which will arise from any method of cutting will contain as much pine as it formerly did. Our present belief is that in order to insure a high proportion of pine in future stands where hardwood invasion is active, cleaning and weeding operations will be required when the new pine growth is about 5 years of age to release the most promising pine seedlings from hardwood competition.

Summary

In the foregoing pages our available facts have been summarized. These show that the leaving of only 3 or 4, 8- or 9-inch seed trees cannot be counted upon to provide within 3 to 5 years as many as 1,000 seedlings per acre in the majority of cuttings. Other facts have been presented to show what types of operation we believe provide the best guarantee of prompt, adequate regeneration of pine stands.

From the standpoint of practical application there is a wide gap between the existing seed tree recommendations in Virginia and the methods suggested which will insure adequate reproduction. The seed tree law is practical in that it can be adhered to by most operations. The recommended measures are impractical in that they cannot be readily adhered to under current methods of operation on many properties. They could be practiced possibly by a private owner managing his own stumpage or by a large company operating on fee lands. They would not be practical for lands where an operating company purchases stumpage only, because either the two-cut method or the partial cutting in strips or groups would require an unusually long term option on the timber. Also such methods are so foreign to present procedures that a state law proposing them would get little or no public support. There may be a middle ground between the extremes represented by the existing seed tree law and the recommended measures which will insure adequate reproduction. Research on this matter has not progressed far enough for us to have found this middle ground and it is not probable that the Appalachian Forest Experiment Station will be able to answer the question under its present financing.

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